U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

15.4.8 RADIOLOGICAL CONSEQUENCES OF A CONTROL ROD EJECTION ACCIDENT (PWR) APPENDIX A

REVIEW RESPONSIBILITIES

Primary - ~~Accident Evaluation Branch (AEB)~~Emergency Preparedness and Radiation Protection Branch (PERB)[1]

Secondary - ~~Core Performance Branch (CPB)~~Reactor Systems Branch (SRXB)[2]

I. AREAS OF REVIEW

The ~~AEB~~PERB[3] review under this appendix covers the following areas:

1. The plant response to a control rod ejection accident.

2. The calculation of whole-body and thyroid doses at the exclusion area boundary (EAB)[4] and low population zone (LPZ)[5] outer boundary due to the releases resulting from a rod ejection accident.

The purpose of the review is (1)[6] to ~~assure~~ensure[7] that the plant procedures for recovery from a rod ejection accident and the plant technical specifications are properly taken into account in computing the whole-body and thyroid doses at the nearest ~~exclusion area boundary (EAB) and low population zone (LPZ)~~EAB and the LPZ[8] outer boundary and (2) to compare the calculated doses against the appropriate guidelines. This review applies to pressurized water reactors (PWR) only.[9]

The standard design certification applicant may make reasonable assumptions regarding certain site parameters such as χ/Q, the EAB, and the LPZ boundary.[10]

For an operating license (OL) or combined license (COL) application, limitations in technical specifications will be reviewed.[11]

Review Interfaces[12]

The PERB will coordinate other branch evaluations that interface with the overall review of the radiological consequences of a control rod ejection accident, as follows:

1. A secondary review is performed by the ~~CPB~~SRXB,[13] and the results are used by ~~AEB~~PERB[14] in the overall evaluation of the accident analysis.

2. The physics and thermal-hydraulic aspects of the accident are reviewed by ~~CPB~~SRXB as part of its primary review responsibility under Standard Review Plan (SRP) Section 15.4.8.[15] Verification of the applicant's calculations of the number of fuel pins experiencing departure from nucleate boiling (DNB) and the amount of fuel reaching the clad melting temperature is provided by the ~~CPB~~SRXB.[16]

3. The χ/Q values are reviewed by PERB as part of its primary review responsibility for SRP Section 2.3.4.[17]

4. The EAB and the LPZ are reviewed by the Civil Engineering and Geosciences Branch (ECGB) as part of its primary review responsibility under SRP Sections 2.1.1, 2.1.2, and 2.1.3.[18]

5. The site characteristics assumed by the design certification applicant will be reviewed by the ECGB as part of its primary review responsibility for SRP Section 2.1.1.[19]

6. Technical specifications are reviewed by the Technical Specifications Branch (TSB) as part of its primary review responsibility for SRP Section 16.0.[20]

II. ACCEPTANCE CRITERIA

1.[21] The acceptance criteria are based on requirements of 10 CFR Part 100 as to mitigating the radiological consequences of an accident. The plant site and dose mitigating engineered safety features are acceptable with respect to the radiological consequences of a postulated control rod ejection accident if the calculated whole-body and thyroid doses at the ~~exclusion area (EAB) and the low population zone (LPZ) boundaries~~EAB and the LPZ boundary[22] are well within the exposure guideline values specified in 10 CFR ~~Part 100, paragraph 11~~100.11 ~~(Ref. 1)~~.[23] "Well within" is defined as 25% of the 10 CFR ~~Part 100~~100.11 exposure guideline values or ~~75 rem~~750 mSv (75 rem)[24] for the thyroid and ~~6 rem~~60 mSv (6 rem)[25] for whole-body doses.

~~A technical specification is required for the leak rate from the primary to secondary coolant system in the steam generators. This specification is acceptable if the calculated potential radiological consequences from the control rod ejection accident are within the exposure guidelines above.~~[26]

The models for calculating the whole-body and thyroid doses are acceptable if they incorporate the appropriate conservative design basis assumptions outlined in Appendix B to Regulatory Guide 1.77[27] ~~(Ref. 2)~~,[28] with the exception of the guidelines for the atmospheric dispersion factors (~~X/Q~~χ/Q[29] values). The acceptability of the ~~X/Q~~χ/Q values is determined under SRP Section 2.3.4.

2. In accordance with 10 CFR 50.36, technical specifications must be provided to define performance limits for equipment required to ensure the safe operation of the facility. A technical specification defining the leak rate from the primary to secondary coolant system in the steam generators must be included. This leak-rate specification is acceptable if the calculated potential radiological consequences from a control rod ejection accident are within the 10 CFR 100.11 exposure guidelines.[30]

Technical Rationale[31]

The technical rationale for application of these acceptance criteria to reviewing the radiological consequences of a control rod ejection accident is discussed in the following paragraphs:

1. Compliance with 10 CFR 100.11 requires that the EAB and the LPZ be defined on the basis of assurances that specified limits will not be exceeded for radiation doses from postulated fission product releases to individuals at the outer boundaries of those regions.

   The requirements of 10 CFR 100.11 apply to this appendix because rod ejection accidents are included among the potential accidents for which fission product releases are postulated. Review under SRP Section 15.4.8 determines the source term to be used by the Appendix A reviewer in evaluating compliance with 10 CFR 100.11. Guidance for determining acceptability of the dose calculations is found in Appendix B to Regulatory Guide 1.77.

   Meeting these requirements provides assurance that offsite radiation doses from a rod ejection accident will not exceed the guideline doses specified in 10 CFR 100.11.[32]

2. Compliance with 10 CFR 50.36 requires that technical specifications be established to define performance limits for equipment required to ensure the safe operation of the facility. These technical specifications are to be derived from safety analyses.

   The requirements of 10 CFR 50.36 apply to this appendix because the limiting value for primary to secondary coolant system leakage as stipulated in the technical specification will be used by the reviewer to compute the offsite radiological dose resulting from a control rod ejection accident. The offsite dose must be within the 10 CFR 100.11 guidelines, otherwise a more stringent leakage rate must be specified. Further guidance regarding acceptable technical specifications is found in the standard technical specifications for PWRs.

   Meeting these requirements provides assurance that offsite radiation doses resulting from a control rod ejection accident will not exceed the guideline doses specified in 10 CFR 100.11.[33]

III. REVIEW PROCEDURES

The reviewer selects and emphasizes specific aspects of this appendix to SRP Section 15.4.8 as are appropriate for the particular plant. The judgment concerning[34] which areas need to be given attention and emphasis is determined by the similarity of the information presented in the ~~SAR~~safety analysis report (SAR)[35] or other licensing submittals to that recently reviewed on other plants and whether items of special safety significance are involved.

The detailed review of the radiological consequences of a rod ejection accident is done at the OL stage when system parameters and accident analysis results are fully developed. At the CP stage, the reviewer estimates the doses from the rod ejection accident based on the review of similar plants that have been recently reviewed. Regulatory Guide 1.77 ~~(Ref. 2)~~[36] is used in the analysis of the control rod ejection accident. In particular, Appendix B of the guide should be used in the evaluation of the radiological consequences. A loss of offsite power is assumed in the analysis. The ~~AEB~~PERB[37] review of the accident includes the following:

1. Review of the applicant's description of the control rod ejection accident:[38] This includes a review of the sequence of events to ~~assure~~ensure[39] that the most severe case from the standpoint of release of fission products to the environment has been analyzed.

2. Evaluation of fuel damage: The ~~Core Performance Branch (CPB)~~SRXB[40] reviews the physics and thermal-hydraulic aspects of the accident. Verification of the applicant's calculations of the number of fuel pins reaching DNB and the amount of fuel reaching the fuel melting temperature are obtained from the ~~CPB~~SRXB.[41] The fuel melting temperature criterion used for release of large fractions of fission gases corresponds to the initiation of melting as opposed to the 280 cal/g~~m~~[42] used as a criterion by the ~~CPB~~SRXB[43] for core disruption. It is assumed that the fission products released to the primary coolant due to fuel failure or melting are instantaneously and uniformly mixed in the primary coolant at the time of the accident.

3. Fission product release path to the environment: Two release~~s~~[44] paths to the environment are considered independently for this accident: first, containment leakage of fission products released from the primary system to the containment; and second, leakage from the secondary system, outside containment, following primary-to-secondary leakage in the steam generators. For releases via the containment building, 100% of the noble gases and 25% of the iodines contained in the fuel which is estimated to reach initiation of melting are assumed to be available for release from the containment. For releases through the secondary system, 100% of the noble gases and 50% of the iodines contained in the fuel which is estimated to reach initiation of melting are assumed to be released to the primary coolant.

4. The standard technical specifications for ~~each of~~ the three PWR vendors' nuclear steam supply systems (NSSSs), ~~include~~ including[45] limits on the primary-to-secondary coolant leak rate: These limits are used by the staff in its dose calculation when plant-specific technical specification limits are not available.

5. Determination of the atmospheric dispersion characteristics (~~X/Q~~χ/Q values): The appropriate ~~X/Q~~χ/Q values are determined by the assigned meteorologist in accordance with SRP Section 2.3.4.

6. Calculation of the EAB and LPZ doses: The reviewer performs an independent calculation of the thyroid and whole-body doses for the two release paths above (i.e., containment leakage and secondary system leakage outside containment).

   The actual doses for the postulated accident would be a composite of the doses computed for the independent releases via the containment building and through the secondary system. However, both doses should be presented. The whole-body and thyroid doses calculated by the staff and the applicant are compared with the acceptance criteria stated in subsection II. If the doses for either release path approach the acceptance criteria, calculation of representative composite cases should be considered (the ~~AEB~~PERB[46] branch chief should be consulted).

   If the doses resulting from the releases through the secondary system exceed the acceptance criteria specified in subsection II above, then a reduction of the technical specification limit on primary-secondary system leakage should be considered. If the doses resulting from the potential releases from the primary containment exceed the specified limits, then a reduction of the pressure setpoint for actuation of the containment sprays may be considered to obtain credit for spray removal of the fission products.

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.[47]

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided by the applicant and that the applicant's analysis and the staff's independent calculations support conclusions such as the following, to be included with the ~~AEB~~ PERB[48] input to the staff's safety evaluation report (SER):[49]

> The staff has reviewed the applicant's analysis of the control rod ejection accident and has performed an independent calculation of the radiological consequences following the accident. The staff concludes that the distances to the exclusion area and to the low population zone boundaries for the (insert PLANT NAME) site, in conjunction with the operation of the dose mitigating engineered safety feature~~ESF~~[50] systems, are sufficient to provide reasonable assurance that the calculated radiological consequences are well within the exposure guidelines as set forth in 10 CFR ~~Part 100, paragraph 11~~100.11.[51]

The staff's conclusion is based on (1) the staff review of the applicant's analysis of the radiological consequences~~;~~;[52] (2) the staff's independent dose calculation utilizing the recommendations of Appendix B ~~of~~to[53] Regulatory Guide 1.77 and the atmospheric dispersion factors as discussed in Chapter 2 of this report~~;~~; and (3) the (insert NSSS vendor) ~~S~~standard ~~T~~technical ~~S~~specifications[54] for the primary-to-secondary leakage in the steam generators. The staff will review the (PLANT NAME)-specific technical specifications to ~~assure~~ensure[55] that the dose guidelines stated above are not exceeded.

For design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP section.[56]

V. IMPLEMENTATION

The following provides guidance to applicants and licensees regarding the staff's plans for using this appendix to SRP Section 15.4.8.

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.[57] Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.[58]

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

VI. REFERENCES

1. 10 CFR ~~Part~~ 100~~, paragraph~~ .11,[59] "Determination of Exclusion Area, Low Population Zone, and Population Center Distance."

2. Regulatory Guide 1.77, "Assumptions Used for Evaluating a Control Rod Ejection Accident for Pressurized Water Reactors," Appendix B, "Radiological Assumptions."

3. NUREG-1430, "Standard Technical Specifications, Babcock and Wilcox Plants," Revision 1, April 1995.[60]

4. NUREG-1431, "Standard Technical Specifications, Westinghouse Plants," Revision 1, April 1995.

5. NUREG-1432, "Standard Technical Specifications, Combustion Engineering Plants," Revision 1, April 1995.

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SRP Draft Section 15.4.8
Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	Current PRB name and abbreviation	Changed PRB to Emergency Preparedness and Radiation Protection Branch (PERB).
2.	Current SRB name and abbreviation	Changed SRB to Reactor Systems Branch (SRXB).
3.	Current PRB designation	Changed PRB to PERB.
4.	Editorial revision	Defined EAB at first place of usage in text.
5.	Editorial revision	Defined LPZ at first place of usage in text.
6.	Editorial revision	Added numbers "(1)" and "(2)" to improve clarity.
7.	Editorial revision	Changed "assure" to "ensure."
8.	Editorial revision	EAB and LPZ were defined at their first usage.
9.	Editorial revision	Added to areas of review a statement that the review applies only to PWRs.
10.	SRP-UDP format item	Inserted additional review area for design certification applicant.
11.	SRP-UDP format item	Included review of technical specifications under AREAS OF REVIEW. A sentence under EVALUATION FINDINGS states that the staff will review technical specifications. This should be done before the FSER is issued.
12.	SRP-UDP format item	Added "Review Interfaces" to AREAS OF REVIEW and provided lead-in paragraph. Provided sequential numbering for individual review areas.
13.	SRP-UDP format item	Corrected review branch abbreviation.
14.	SRP-UDP format item	Changed PRB to PERB.
15.	Editorial revision	Added wording to clarify that the identified review is performed under a different review plan.
16.	SRP-UDP format item	Corrected the review branch designation.
17.	SRP-UDP format item	Added an interface for the meteorology review because a review procedure identifies this review.
18.	SRP-UDP format item	Added an interface for SRP sections addressing the exclusion area and the low population zone because a sentence in EVALUATION FINDINGS implies that the reviewer must verify that the distances to the boundaries of these zones are acceptable.
19.	SRP-UDP format item	Added a review interface with the new SRP Section 2.3.6, which reviews the design certification applicant's site envelope.

Item	Source	Description
20.	SRP-UDP format item	Added a review interface with SRP Section 16.0 because it contains an acceptance criterion for technical specifications.
21.	Editorial addition	Numbered the acceptance criteria; the second acceptance criterion has been added to address the technical specification requirement
22.	Editorial revision	EAB and LPZ are defined at their first usage. EAB boundary is redundant, thus the sentence was revised slightly.
23.	SRP-UDP format item	Standardized the citation for the Code of Federal Regulations and deleted the unnecessary reference callout.
24.	SRP-UDP format item	Converted rems to millisieverts.
25.	SRP-UDP format item	Converted rems to millisieverts.
26.	Editorial revision	Moved paragraph to this location as the second acceptance criterion to provide continuity to the discussion of dose calculations.
27.	SRP-UDP format item	Appendix B to Regulatory Guide 1.77 refers to an outdated standard: ICRP 2 1959.
28.	SRP-UDP format item	Deleted unnecessary reference callout.
29.	Editorial revision	Changed X to χ
30.	Editorial revision	Added a second acceptance criterion as the basis for the technical specification requirement. (Part 100 does not require technical specifications.)
31.	SRP-UDP format item	Added "Technical Rationale" to ACCEPTANCE CRITERIA and provided an introductory paragraph.
32.	SRP-UDP format item	Provided the technical rationale for 10 CFR 100.11.
33.	SRP-UDP format item	Provided the technical rationale for 10 CFR 50.36.
34.	Editorial revision	Added a word to facilitate understanding.
35.	Editorial revision	Defined SAR at its first place of usage.
36.	SRP-UDP format item	Deleted unnecessary reference callout.
37.	Current PRB designation	Changed PRB to PERB.
38.	Editorial revision	Underscored a series of review items to provide emphasis.
39.	Editorial revision	Changed "assure" to "ensure."
40.	SRP-UDP format item	Updated review branch designation to SRXB.
41.	SRP-UDP format item	Updated review branch designation.

Item	Source	Description
42.	Editorial revision	The preferred abbreviation for gram is "g," not "gm."
43.	SRP-UDP format item	Updated review branch designation.
44.	Editorial revision	Corrected a spelling error.
45.	Editorial revision	Eliminated "each of" as superfluous, defined NSSS, and modified to provide parallel construction with other items under REVIEW PROCEDURES.
46.	Current PRB designation	Changed PRB to PERB.
47.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
48.	Current PRB designation	Changed PRB to PERB.
49.	Editorial revision	SER has been defined.
50.	Editorial revision	Spelled out "engineered safety feature," which had not previously been defined.
51.	Editorial revision	Changed the CFR citation to the standard format.
52.	Editorial revision	Separated items with semicolons rather than commas because of their complexity.
53.	Editorial revision	Changed "of" to "to."
54.	Editorial revision	Deleted capitalization of standard technical specifications.
55.	Editorial revision	Changed "assure" to "ensure."
56.	SRP-UDP Format Item, Implement 10 CFR 52 Related Changes	To address design certification reviews a new paragraph was added to the end of the Evaluation Findings. This paragraph addresses design certification specific items including ITAAC, DAC, site interface requirements, and combined license action items.
57.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.
58.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.
59.	Editorial revision	Simplified citation format used for Code of Federal Regulations.
60.	Editorial revision	Added reference information for standard technical specifications referred to in Review Procedure 4.

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SRP Draft Section 15.4.8

Attachment B - Cross Reference of Integrated Impacts

Integrated Impact No.	Issue	SRP Subsections Affected
	No Integrated Impacts were incorporated in this SRP Section.	